

**INSTITUTO  
FEDERAL**

Ceará

**INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA DO CEARÁ**

**CAMPUS XXXX**

**CURSO DE LICENCIATURA EM XXXX**

**NOME SOBRENOME**

**TÍTULO DO TRABALHO**

**ACARAÚ**

**2020**

NOME SOBRENOME

TÍTULO DO TRABALHO

Trabalho de Conclusão de Curso apresentado ao Curso de Licenciatura em Xxxx do Campus Xxxx do Instituto Federal de Educação, Ciência e Tecnologia do Ceará, como requisito parcial à obtenção do grau de licenciado em Xxxx.

Orientador: Dr. XXXXXX XXXXX XXXXXX

ACARAÚ

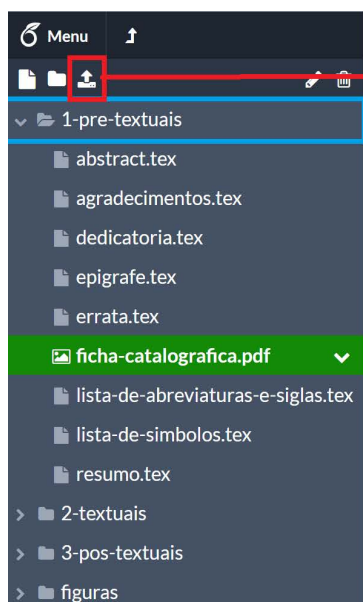
2020

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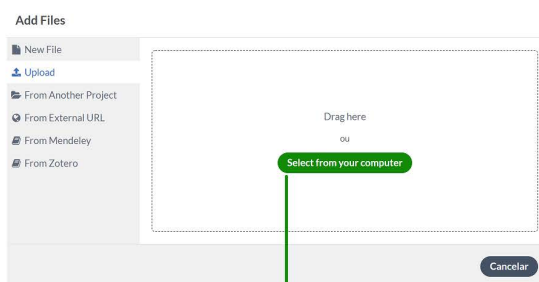
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## ERRATA

NOME SOBRENOME

TÍTULO DO TRABALHO

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Aprovada em:

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do Ceará (IFCE)

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Dr. XXXXXXX XXXXXX XXXXXXX  
Universidade do Membro da Banca Três (SIGLA)

Texto da dedicatória.

## **AGRADECIMENTOS**

Texto do agradecimento

“Texto da epígrafe”

(Autor)



## RESUMO

Texto do resumo.

**Palavras-chave:** Palavra-chave 1. Palavra-chave 2. Palavra-chave 3.

## **ABSTRACT**

Abstract text.

**Keywords:** Keyword 1. Keyword 2. Keyword 3.

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## **LISTA DE ABREVIATURAS E SIGLAS**

PDF *Portable Document Format*



## LISTA DE SÍMBOLOS

$A_e$	Área efetiva da antena
$B$	Largura de faixa em que o ruído é medido em Hertz
$d$	Distância em metros
$E$	Campo elétrico
$FA$	Fator da antena
$Gr$	Ganho de recepção
$h$	Altura efetiva ou comprimento efetivo de uma antena
$I$	Corrente elétrica
$k$	Constante de Boltzmann's
$K$	Eficiência de irradiação
$M$	Variação do patamar de ruído em função da RBW
$N$	Condutor de neutro
$NF$	Figura de ruído
$N_i$	Potência do ruído na entrada
$N_o$	Potência do ruído na saída
$P$	Potência
$R$	Resistência
$S_i$	Potência do sinal na entrada
$S_o$	Potência do sinal na saída
$t$	Tempo
$V$	Tensão
$Z_L$	Impedância da antena
$Z_o$	Impedância de referência ( $50\Omega$ )
$\lambda$	Comprimento de onda
$\Gamma$	Coefficiente de reflexão

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## 1 INTRODUÇÃO

## **2 REFERENCIAL TEÓRICO**

### **2.1 Seção 1**

### **2.2 Seção 2**

### **2.3 Seção 3**

### **3 JUSTIFICATIVA**

## **4 OBJETIVOS**

### **4.1 Objetivo Geral**

- Objetivo Geral.

### **4.2 Objetivos Específicos**

- Objetivo específico 1;
- Objetivo específico 2.

## **5 METODOLOGIA**

### **5.1 Seção 1**

### **5.2 Seção 2**

### **5.3 Seção 3**

## **6 RESULTADOS E DISCUSSÃO**

### **6.1 Seção 1**

### **6.2 Seção 2**

### **6.3 Seção 3**



## **7 CONCLUSÃO**

## REFERÊNCIAS

## **APÊNDICE A – EXEMPLO DE APÊNDICE**

Um apêndice é um documento elaborado pelo autor, diferentemente do anexo. Geralmente, se coloca como apêndice, questionários, códigos de programação, tabelas que tomariam muito espaço no meio do trabalho. Artigos, resumos ou qualquer publicação relacionada ao trabalho podem ser utilizados como apêndice.

## APÊNDICE B – QUESTIONÁRIO UTILIZADO PARA...

**Questão 1.** Esta é a primeira questão com alguns itens:

- (a) Este é o primeiro item
- (b) Segundo item

**Questão 2.** Esta é a segunda questão:

- (a) Este é o primeiro item
- (b) Segundo item

**Questão 3.** Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nunc dictum sed tortor nec viverra. consectetur adipiscing elit. Nunc dictum sed tortor nec viverra.

- (a) consectetur
- (b) adipiscing
- (c) Nunc
- (d) dictum

## APÊNDICE C – CÓDIGOS-FONTES UTILIZADOS PARA...

### Código-fonte 1 – Hello World em C++

```
1 #include <iostream>
2 using namespace std;
3 int main() {
4     cout<<"Hello World!"<<endl;
5     system("pause");
6 }
```

### Código-fonte 2 – Hello World em Java

```
1 public class HelloWorld {
2     public static void main(String[] args) {
3         System.out.println("Hello World!");
4     }
5 }
```

**APÊNDICE D – IEEE CEFC 2016**

*Digest submetido ao The 17th Biennial Conference on Eletromagnetic Field Computation, Miami FL - NOV 13-16, 2016, USA.*

# Lightning Incidence Model Based on the Electric Field Gradient: 3D Electrostatic Analyses

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**Abstract**— The paper deals with the 3D electrostatic analysis of a lightning strike in a hangar and a power transmission line. The lightning incidence model is based on the electric field gradient. Finally, the simulation results are described and discussed.

**Index Terms**—Lightning, Electrostatic, Finite element.

## I. INTRODUCTION

In [1], a 2D electrostatic analysis of a new lightning incidence model based on the electric field gradient (EFG) was presented. Moreover, the simulations results were carried out for a building and a power transmission line and they were compared with the classical electrogeometrical model (EGM), the rolling-sphere technique (RST) and the leader progression model (LPM) [2]. The present paper estimates the trajectory of lightning strikes from the thundercloud to a grounded metal roof of a hangar. Furthermore, the same procedure will be carried out for 500kV power transmission lines.

## II. ELECTROSTATIC ANALYSES

A lightning occurs when the electric field is higher than the breakeven field (400kV/m—3MV/m) [2]. This model is based on the electric field gradient described by

$$\vec{E}_L(\vec{r}) \approx \vec{E}_b(\vec{r}) + \lambda_t \nabla E_b(\vec{r}), \quad (1)$$

$\vec{E}_b(\vec{r})$  is the background electric field, which is function of the position  $\vec{r}$  and it is generated by the electric potential difference (EPD) between the cloud and the ground.  $\lambda_t$  is the lightning step length (~50m) [3], and  $\vec{E}_L(\vec{r})$  is the lightning electric field. More details about Eq. (1) can be found in [1].

A 3D finite element method (FEM) model of a hangar and a power transmission line (TL) were designed by using the electrostatic module. All simulations were carried out within a cubic domain of 250m x 250m x 250m. The upper level of each domain is defined with -12.5MV, while the lower level is the ground. This is equivalent to a real thundercloud with a potential of (-100MV) at 2km of altitude [4].

The dimensions of the hangar are: 8.60m height, 77.37m width and 229.00m length. The aluminum metal roof has 0.7mm thickness and it is grounded. The second simulation is for a TL composed by three phase conductors, equally spaced by 11.5m and positioned at 40.5m above the reference plane. The TLs are protected by two earth wires spaced by 19m over 54.47m of the reference plane.

## III. RESULTS

In order to evaluate the 3D model, the software COMSOL Multiphysics® was used in a computer with quad-core processor of 2.6GHz. For the hangar, the simulation time was around 4s. The necessary physical memory for the simulation

was 1.34GB and 5.6GB of virtual memory. The electric field is very intense at the roof (about 80MV/m) and the lightning (cyan lines) strikes the building roof, as shown in Fig. 1a. In summary, it is not necessary to add air terminals, as long the roof is grounded. The simulation time for the TL was around 6 min, using 15GB of physical memory and 32GB of virtual memory. As shown in Fig 1b, the cyan lines strike the earth wires.

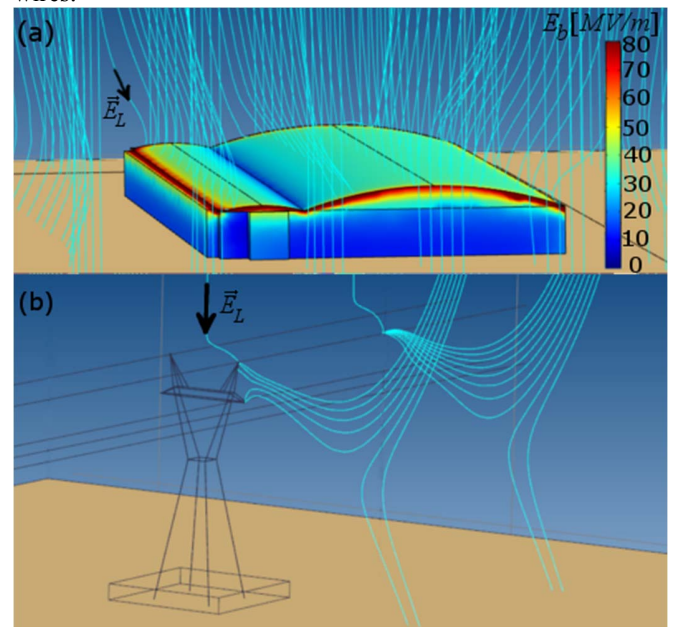


Fig. 1. Case of studies: (a) hangar and (b) power transmission line.

## IV. CONCLUSIONS

The EFG simulations predicted that the aluminum metal roof is able to protect the hangar against lightning strikes. In the TL simulation, the earth wires have fulfilled the protection for the phase conductors. Finally, the protection zone and the design of lightning protection system can be evaluated by 3D electrostatic analyses, which are closer to the reality than the 2D analyses. However, 3D models are often more complex and require more simulation time.

## REFERENCES

- [1] E. M. Rodrigues, *Novel Lightning Incidence Model Based on the Electric Field Gradient: 2D Electrostatic Analyses*. GROUND'2016 & 7<sup>th</sup> LPE. 2016.
- [2] V. Cooray, *Lightning protection*, The Institution of Engineering and Technology. 2009.
- [3] V.A. Rakov and M. A. Uman, *Lightning: physics and effects*. Cambridge University Press. 2007.
- [4] S. Visacro, *Descargas atmosféricas: Uma Abordagem de Engenharia (Lightning strike: An Engineering approach)*, Artliber, 2005.

## ANEXO A – EXEMPLO DE UM ANEXO

Um anexo é um documento que não foi elaborado pelo autor, ou seja, o autor apenas anexa. Anexos podem ser tabelas, mapas, diagramas, *datasheets*, manuais e etc.



## ANEXO B – EXEMPLO DE UM ANEXO EM PDF

O autor pode anexar um *Portable Document Format* (PDF), traduzido como formato portátil de documento. Veja o código fonte utilizado para anexar o arquivo “Sikasil.pdf” que foi colocado dentro da pasta “anexos” que por sua vez está dentro da pasta “elementos-pos-textuais”. Tenha muita atenção na hora de especificar o local do arquivo. Recomenda-se não utilizar caracteres especiais para nomear pastas e, principalmente, arquivos.

Pode-se fazer uma descrição sucinta do arquivo anexado.

# Sikasil® GS-630

## Glazing sealant for structural & non-structural use

### Technical Product Data

Chemical base	1-C silicone	
Color (CQP <sup>1</sup> 001-1)	See Product Overview	
Cure mechanism	Moisture-curing	
Cure type	Neutral	
Density (uncured) (CQP 006-4)	1.4 kg/l approx.	
Non-sag properties (CQP 061-4 / ISO 7390)	< 2 mm approx.	
Application temperature	5 - 40°C (41 - 104°F)	
Skin time <sup>2</sup> (CQP 019-2)	10 min approx.	
Tack-free time <sup>2</sup> (CQP 019-1)	60 min approx.	
Curing speed (CQP 049-1)	See diagram 1	
Shore A-hardness (CQP 023-1 / ISO 868)	32 approx.	
Tensile strength (CQP 036-1 / ISO 37)	1.2 N/mm <sup>2</sup> approx.	
Elongation at break (CQP 036-1 / ISO 37)	480% approx.	
Tear propagation resistance (CQP 045-1 / ISO 34)	6 N/mm approx.	
100% modulus (CQP 036-1 / ISO 37)	0.6 N/mm <sup>2</sup> approx.	
Movement accommodation capability (ASTM C 719)	±50%	
Thermal resistance (CQP 513-1)	long term	180°C (356°F) approx.
Short term	4 h	200°C (392°F) approx.
	1 h	220°C (428°F) approx.
Service temperature	-40 - 150°C approx. (-40 - 302°F)	
Shelf life (storage below 25°C) (CQP 016-1)	15 months	

<sup>1)</sup> CQP = Corporate Quality Procedure

<sup>2)</sup> 23°C (73°F) / 50% r.h.

### Description

Sikasil® GS-630 is a durable, neutral-curing silicone sealant and adhesive which combines mechanical strength with high elongation. It adheres excellent to a wide range of substrates.

Sikasil® GS-630 is manufactured in accordance with ISO 9001 quality assurance system and the responsible care program.

### Product Benefits

- Outstanding UV and weathering resistance
- Excellent adhesion to glass, coated glass, metals and plastics
- Fast curing
- Long-term durability
- High movement capability

### Areas of Application

Sikasil® GS-630 is a silicone sealant and adhesive designed for sealing, bonding and mending tasks in a wide variety of industrial applications, e. g. structural and nonstructural applications in facades.

This product is suitable for professional experienced users only. Tests with actual substrates and conditions have to be performed to ensure adhesion and material compatibility.

Industry



## Cure Mechanism

Sikasil® GS-630 cures by reaction with atmospheric moisture. The reaction thus starts at the surface and proceeds to the core of the joint. The curing speed depends on the relative humidity and the temperature (see diagram 1 below). Heating above 50°C to speed-up the vulcanization is not advisable as it may lead to bubble formation. At low temperatures the water content of the air is lower and the curing reaction proceeds more slowly.

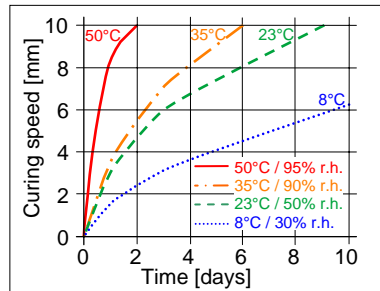


Diagram 1: Curing speed 1C-Sikasil®

## Application Limits

All Sikasil® WS, FS, SG, IG, WT and other engineering silicone sealants and adhesives are compatible with each other. Sikasil® WS and FS sealants as well as other Sika engineering silicone sealants are compatible with SikaGlaze® IG sealants. All other sealants have to be approved by Sika before using them in combination with Sikasil® GS-630. Where two or more different reactive sealants are used, allow the first to cure completely before applying the next.

Do not use Sikasil® GS-630 on pre-stressed polyacrylate and polycarbonate elements as it may cause environmental stress cracking (crazing).

The compatibility of gaskets, backer rods and other accessory materials with Sikasil® GS-630 must be tested in advance.

Joints deeper than 15 mm should be avoided.

The above information is offered for general guidance only. Advice on specific applications will be given on request.

## Method of Application

### Surface preparation

Surfaces must be clean, dry and free from oil, grease and dust.

Advice on specific applications and surface pretreatment methods is available from the Technical Service Department of Sika Industry.

### Application

After suitable joint and substrate preparation, Sikasil® GS-630 is gunned into place. Joints must be properly dimensioned as changes are no longer possible after construction. For optimum performance the joint width should be designed according to the movement capability of the sealant based on the actual expected movement. The minimum joint depth is 6 mm and a width / depth ratio of 2:1 must be respected if used for weatherproofing. For backfilling it is recommended to use closed cell, sealant compatible foam backer rods e.g. high resilience polyethylene foam rod. If joints are too shallow for backing material to be employed, we recommend using a polyethylene tape. This acts as a release film (bond breaker), allowing the joint to move and the silicone to stretch freely.

For more information please contact the Technical Service Department of Sika Industry.

### Tooling and finishing

Tooling and finishing must be carried out within the skin time of the adhesive.

When tooling freshly applied Sikasil® GS-630 press the adhesive to the joint flanks to get a good wetting of the bonding surface.

### Removal

Uncured Sikasil® GS-630 may be removed from tools and equipment with Sika® Remover-208 or another suitable solvent. Once cured, the material can only be removed mechanically.

Hands and exposed skin should be washed immediately using Sika® Handclean Towel or a suitable industrial hand cleaner and water. Do not use solvents!

### Overpainting

Sikasil® GS-630 cannot be over-painted.

## Further Information

Copies of the following publications are available on request:

- Material Safety Data Sheet

## Packaging Information

Unipack	600 ml
Cartridge	300 ml
Pail	26 kg
Drum	280 kg

## Value Bases

All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.

## Health and Safety Information

For information and advice regarding transportation, handling, storage and disposal of chemical products, users should refer to the actual Material Safety Data Sheets containing physical, ecological, toxicological and other safety-related data.

## Legal Notes

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika's recommendations. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The user of the product must test the product's suitability for the intended application and purpose. Sika reserves the right to change the properties of its products. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users must always refer to the most recent issue of the local Product Data Sheet for the product concerned, copies of which will be supplied on request.

Further information available at:

[www.sika.ch](http://www.sika.ch)

[www.sika.com](http://www.sika.com)

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